

The depth of hydrothermal circulation at slow-spreading ridges traced by chlorine in basalt

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Hydrothermal circulation is an active process at all mid-ocean ridges, but its depth extent is less certain, which is important for mass and energy balances (i.e. cooling) of newly formed oceanic crust. The depth of hydrothermal alteration of the oceanic crust can indirectly be traced by raised chlorine (Cl) contents of basalts, if their magmas assimilated hydrothermally altered crust and by the use of petrologic arguments, which determine the depth of this assimilation.

An earlier study by Michael and Schilling (1989) on chlorine indicated a restricted depth for hydrothermal circulation, as slow-spreading ridges - that have crystallization depths of mostly >300 MPa - did not display Cl enrichment in contrast to shallower magmas from fast-spreading ridges. However, the intrinsically lower Cl concentrations (50-200 ppm) in basalts from slow-spreading ridges make the tracing of crustal assimilation more arduous there.

We performed high precision Cl measurements on basalts from 3 slow spreading ridges : the Southern Mid-Atlantic Ridge (3 cm/yr), the Red Sea Rift (max. 1.6 cm/yr) and the Western Gakkel Ridge (max. 1.5 cm/yr). Chlorine contents vary from 40 to 400, 700 and 1300 ppm respectively, and the rocks display elevated Cl compared to elements of similar incompatibility over the full range of crystallization depths, suggesting that assimilation of hydrothermally altered crust is occurring unrelated to crystallization pressures and down to the lower crust.

The observed differences in the degree of Cl enrichment between these three ridges, suggest other influencing factors than pressure alone in the visibility of assimilation of hydrothermally altered crust. High salinity, the presence of brine pools and evaporites together with active magmatism increases Cl enrichment, while trace-element-enriched magmas (higher primordial Cl) are less sensitive to Cl enrichment due to assimilation.